OCEAN ENGINEERING DIVISION

UNITED STATES COAST GUARD

WASHINGTON, D.C.

AUGUST 2007

SPECIFICATION FOR FABRICATION

OF

IONOMER FOAM BUOYS

SPECIFICATION NO. 450

REVISION F

1. SCOPE

1.1 General. This specification describes the requirements for fabrication of lighted and unlighted ionomer foam buoys. The buoys will be used as aids to navigation in the navigable waters of the United States.

1.2 Buoy classification. The buoys covered by this specification are classified as either lighted or unlighted. Lighted buoys are identified by their overall diameter and length and various design attributes. Unlighted buoys are identified by their class (2nd through 6th in descending order of size), shape, and design attributes. The type and description of the buoys covered by this specification are listed in Table I.

Table I Buoy Type and Description

Type	Description
2NFR	Second Class Nun Foam Radar Reflective
2CFR	Second Class Can Foam Radar Reflective
3NFR	Third Class Nun Foam Radar Reflective
3CFR	Third Class Can Foam Radar Reflective
4NFR	Fourth Class Nun Foam Radar Reflective
4CFR	Fourth Class Can Foam Radar Reflective
5NFR	Fifth Class Nun Foam Radar Reflective
5CFR	Fifth Class Can Foam Radar Reflective
6NFR	Sixth Class Nun Foam Radar Reflective
6CFR	Sixth Class Can Foam Radar Reflective
6NTFR	Sixth Class Nun Tall Foam Radar Reflective
6CTFR	Sixth Class Can Tall Foam Radar Reflective
FWNFR	Fast Water Nun Foam Radar Reflective
FWCFR	Fast Water Can Foam Radar Reflective
5x9 LNFR	5x9 Lighted Nun Foam Radar Reflective
5x9 LCFR	5x9 Lighted Can Foam Radar Reflective
6x18 LNFR	6x18 Lighted Nun Foam Radar Reflective
6x18 LCFR	6x18 Lighted Can Foam Radar Reflective
8x21 LNFR	8x21 Lighted Nun Foam Radar Reflective
8x21 LCFR	8x21 Lighted Can Foam Radar Reflective

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are referenced in sections 3 and 4 of this specification. This section does not include documents cited in other sections of this specification. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all requirements cited in sections 3 and 4, whether or not the referenced documents are listed here.

2.2 Coast Guard Documents. The following United States Coast Guard Office of Civil Engineering documents form a part of this specification to the extent referenced herein. Suffixes denoting the specific issue of each document are omitted from future references to the documents in this specification.

Specification	Revision	Date	Title
374	E	March 2000	Fabrication of Aluminum Radar Reflectors
460	G	April 2002	Fabrication of Buoy Solar Battery Boxes
393	A1	May 1996	High Intensity Retroreflective Films, Change 1

2.3 Other Government Documents. The following documents form a part of this specification to the extent referenced herein. Suffixes denoting the specific issue of each document are omitted from future references to the documents in this specification.

SPECIFICATIONS

MIL-P-24647B 9 August 1994	Paint System, Anticorrosive and Antifouling, Ship Hull
QPL-24647-10 25 May 2006	Qualified Products List of Products Qualified Under Military Specification MIL-P-24647, Paint System, Anticorrosive and Antifouling, Ship Hull

STANDARDS

FED-STD-595B 11 January 1994	Federal Standard Colors

2.4 Industry Publications. The following documents form a part of this specification to the extent referenced herein. Suffixes denoting the specific issue of each document are omitted from future references to the documents in this specification.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

A36-2005	Standard Specification for Carbon Structural Steel
A153-2005	Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
A666-2003	Standard Specification for Annealed or Cold Worked Austenitic Stainless

Steel Sheet, Strip, Plate and Flat Bar
B209-2006 Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
B221-2005 Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
D1630-2006 Standard Test Method for Rubber Property-Abrasion Resistance (Footwear Abrader)
D2240-2005 Standard Test Method for Rubber Property-Durometer Hardness
D3575-2000 Standard Test Methods for Flexible Cellular Materials Made from Olefin Polymers
G155-2005 Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials

AMERICAN WELDING SOCIETY (AWS)

ANSI/AWS D1.1-2000 Structural Welding Code – Steel (Hereafter referred to as AWS D1.1)
ANSI/AWS D1.2-2003 Structural Welding Code – Aluminum (Hereafter referred to as AWS D1.2)

AMERICAN SOCIETY FOR QUALITY

ANSI/ISO/ASQC Q9002-1994 Quality Systems (Hereafter referred to as Q9002)

STEEL STRUCTURES PAINTING COUNCIL (SSPC) (Hereafter referred to as SSPC-SP-10)

SSPC-SP-10 Near White Blast Cleaning

INTERNATIONAL COMMISSION ON ILLUMINATION

CIE No. 15:2004 Colorimetry, Third Edition

2.5 Drawings. The following United States Coast Guard Office of Civil Engineering drawings form a part of this specification to the extent referenced herein, and shall be referred to as "the drawings" throughout this specification.

Drawing Number	Revision	Title
120316	F	Nun Shape Aluminum Radar Reflector
121024	G	Can Shape Aluminum Radar Reflector
121100	L	Solar Buoy Double Battery Box
121148	E	1991 Type, 5x9LCFR and 5x9LNFR, Lighted Foam Buoys
121166	E	1995 Type, 2CFR and 2NFR, Unlighted Foam Buoys
121167	D	1995 Type, 3CFR and 3NFR, Unlighted Foam Buoys
121168	C	1995 Type, 4CFR and 4NFR, Unlighted Foam Buoys
121169	D	1995 Type, 5CFR and 5NFR, Unlighted Foam Buoys
121170	D	1995 Type, FWNFR and FWCFR, Unlighted Foam Buoys
121171	C	1995 Type, 6CFR and 6NFR, Unlighted Foam Buoys
121181	A	1998 Type, 6CTFR and 6NTFR, Unlighted Foam Buoys

121184	--	2007 Type 6x18 LFR Buoy
121185	--	2007 Type 8x21 LFR Buoy

2.6 Source of documents. The documents may be obtained from the following sources:

Coast Guard documents
Commandant (CG-432B)
U.S. Coast Guard Headquarters
2100 Second Street, S.W.
Washington, DC 20593-0001

Government documents
Standardization Documents Order Desk
Building 4, Section D
700 Robbins Avenue
Philadelphia, PA 19111-5094

Industry publications

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)
1916 Race Street
Philadelphia, PA 19103-1187

AMERICAN WELDING SOCIETY (AWS)
550 N.W. LeJeune Road
P.O. Box 351040
Miami, FL 33135

AMERICAN SOCIETY FOR QUALITY (ASQ)
611 East Wisconsin Avenue
Milwaukee, WI 53202

AMERICAN SOCIETY FOR NON-DESTRUCTIVE TESTING (ASNT)
4153 Arlington Plaza
Columbus, OH 43228

STEEL STRUCTURES PAINTING COUNCIL (SSPC)
4400 Fifth Avenue
Pittsburg, PA 15213-2683

UNITED STATES NATIONAL COMMITTEE OF THE CIE
c/o Ronald B. Gibbons, Virginia Tech Transportation Institute
3500 Transportation Research Place
Blacksburg, VA 24061
U.S.A.
e-mail: gibbons@vtti.vt.edu
Website: http://www.cie-usnc.org

2.7 Precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 General. The buoys shall be fabricated in accordance with the drawings and shall meet the requirements of this specification. The buoys shall be manufactured from ionomer foam and shall have steel and aluminum hardware.

3.2 Ionomer foam. Ionomer foam used in the buoys shall be made of Surlyn ionomer resin 9720 or 9721 (Surlyn is a registered trademark of the Dupont Company) or Iotek ionomer resin 7020 or 7030 (Iotek is a registered trademark of the Exxon Chemical Company). The ionomer foam shall consist of an expanded structure of individual non-connecting cells. The cells shall be closed, with the exception of those on the periphery of each foam piece that may be cut or broken during fabrication. The contractor may propose the use of repeletized virgin ionomer foam in the buoys; the resultant ionomer foam shall be subjected to the entire battery of First Article tests at the contractor's expense. Repeletized virgin ionomer foam material may be used in the buoys if the resultant ionomer foam passes all performance requirements as described in Table IV.

3.2.1 Method of fabrication. The foam shall be extruded into colored sheets having a density of at least 4 pounds per cubic foot (pcf) and be between 1/8" and 3/8" thick. The extruded sheets shall be spirally wrapped into the cylindrical shapes as shown on the drawings. Each layer shall be continuously heat sealed onto the previous layer over the entire length and circumference of the shape. The conical upper portion of the nun buoys shall be made by trimming or cutting the cylinders into the required shapes shown on the drawings. The completed foam sections of the buoys shall be free from cracks, holes, gouges, and embedded foreign material.

3.2.2 Protective outer skin. The entire circumference of each buoy shall have a protective outer skin. This outer skin shall be a denser composition of the inner foam layers. This skin shall be produced by "densifying" the outer surface of the buoy by extracting gas from the foam using a combination of pressure and heat. The resulting high density, pigment-rich outer skin shall have a minimum density of 30 pcf and a thickness between 1/4" and 5/16". The final diameter of the finished hull shall be as specified in the drawings.

3.2.3 Protective end caps. The ends of the cylinders shall have a densified outer skin identical to that described in paragraph 3.2.2. This shall be accomplished by heat welding 4 pcf foam

sheets to the top and bottom of the cylindrical shapes prior to densification. These sheets shall be cut to the pre-densified buoy diameter so that they are rolled over the circumferential edges to form a fortified shoulder during densification. The end caps shall be identical in properties and color to the interior foam used to fabricate the cylindrical shapes and shall likewise have a density of 30 pcf with a thickness between 1/4" and 5/16".

3.2.4 Final densification. Final densification and heat compacting of all surfaces shall be performed to properly finish and fortify the ends, shoulders, and sides of the cylindrical shapes.

3.2.5 Color. The completed spirally wrapped foam parts shall be comprised of layers of foamed sheets conforming to the colors of FED-STD-595 as shown in Table II. Pigments shall be added to the foam during the sheet extrusion process and the colors shall be continuous throughout the entire volume of the foam. The colors shall be within the appropriate chromaticity region specified in Table III and shall remain within this region after continuous exposure to the sun for at least 8 years. Buoys with special color requirements are described in paragraphs 3.10 and 3.11.

Table II FED STD Colors

Red	11350	Yellow	13655
Light Green	14193	White	17875
Dark Green	14062		

Table III Chromaticity Regions

	1		2		3		4		
	x	y	x	y	x	y	x	y	y
Red	0.690	0.310	0.595	0.315	0.569	0.341	0.655	0.345	10-15
Light Green	0.275	0.550	0.275	0.450	0.225	0.450	0.225	0.550	12-24
Dark Green	0.280	0.450	0.260	0.300	0.245	0.300	0.240	0.450	1-5
Yellow	0.522	0.477	0.470	0.440	0.427	0.483	0.465	0.534	48-60
White	0.350	0.360	0.300	0.310	0.290	0.320	0.340	0.370	80-95

Note: Coordinates shall be plotted on CIE 1931 color space. Make colorimetric measurements using 45/0 geometry, a 2 degree observer, and CIE standard illuminant D_{65}. (CIE No. 15:2004)

3.2.5.1 Ultraviolet stabilization. Ultraviolet stabilizers shall be added to the ionomer resin to enhance color retention and to protect the foam from degradation due to continuous exposure to the sun. These stabilizers shall provide ultraviolet protection for a minimum of 8 years.

3.2.6 Impact resistance. The buoy shall be able to withstand the test described in paragraph

4.4.3.3 without sustaining any permanent damage such as cracks, tears, delaminations, separations, or gouges.

3.2.7 Colorfastness. After being subjected to the colorfastness test described in paragraph 4.4.1, the color of the foam shall remain within the appropriate chromaticity regions specified in Table III. The colorfastness test will be performed in accordance with ASTM G155-05a, Table X3.1, Cycle 7.

3.2.8 Density. Density of the foam shall be as specified in Table IV when tested in accordance with ASTM D3575, Suffix W, Method A.

3.2.9 Tensile strength. Tensile strength of the foam, when measured in the horizontal, vertical, and radial directions, shall be as specified in Table IV when tested in accordance with ASTM D3575, Suffix T.

3.2.10 Tear strength. Tear strength, measured in the horizontal, vertical, and radial directions, shall be as specified in Table IV when tested in accordance with ASTM D3575, Suffix G.

3.2.11 Compression set. Compression set of the foam shall be as specified in Table IV when tested in accordance with ASTM D3575, Suffix B.

3.2.12 Compression load deflection. Compression load deflection of the foam shall be as specified in Table IV when tested in accordance with ASTM D3575, Suffix D.

3.2.13 Hardness. Hardness of the protective outer skin shall be as specified in Table IV when tested in accordance with ASTM D2240.

3.2.14 Abrasion resistance. Abrasion resistance of the protective outer skin shall be as specified in Table IV when tested in accordance with ASTM D1630.

3.2.15 Water absorption. Water absorption of the foam shall be as specified in Table IV when tested in accordance with paragraph 4.4.2.

Table IV Performance Requirements

Parameter	Test Method	Required Value
Colorfastness	G155-05a, Table X3.1, Cycle 7	As specified in Table III
Density	D3575, Suffix W, Method A	4.0 ± 0.5 pcf
Tensile Strength	D3575, Suffix T	Vertical - 150.0 psi min Horizontal - 75.0 psi min Radial - 90.0 psi min.
Tear Strength	D3575, Suffix G	Vertical - 35.0 psi min Horizontal - 20.0 psi min Radial - 45.0 psi min.
Compression Set	D3575, Suffix B	25.0% max.
Compression Load Deflection	D3575, Suffix D	Radial to 75% - 7.5 psi min
Hardness	D2240	60 ± 5
Abrasion Resistance	D1630	100 min.
Water Absorption	Paragraph 4.4.2	15.0% max.

3.3 Metal hardware. All stainless steel hardware shall meet the requirements of ASTM A666, class 316 or 316L. All other steel shall meet the requirements of ASTM A36. All parts shall be free of cracks from fabrication or material defects. Galvanized steel parts shall be cleaned and hot dip galvanized in accordance with ASTM A153. Aluminum plate and sheet shall meet the requirements of ASTM B209, Alloy 5086 H32. All aluminum rod shall meet the requirements of ASTM B221, Alloy 5086 H111. All sharp corners and edges shall be rounded over.

3.3.1 Internal radar reflectors. The radar reflectors for unlighted buoys shall be Mobri Marine M3 or M4, or equivalent, as specified in the drawings. Radar reflectors shall be installed in the buoys by inserting them into preformed slots of the appropriate size. The slots may be either cut or melted into the can or nun upper body, as shown on the drawings. A plug of foam shall be inserted to completely and snugly fill the gap between the bottom of the radar reflector and the outer surface of the buoy body.

3.3.2 External radar reflector. The external radar reflectors required for the 5x9 LFR shall be manufactured in accordance with U.S. Coast Guard Office of Civil Engineering Specification No. 374. External radar reflectors required for the 6x18 LFR and the 8x21 LFR shall be manufactured in accordance with the U.S. Coast Guard Ocean Engineering Drawing Numbers 121184 and 121185 respectfully. This shall be accomplished by heat welding 4 pcf ionomer foam sheets together with aluminum foil layered inside to provide the required radar reflectivity.

3.3.3 Buoy solar battery box. The buoy solar battery box required for the 5x9 LFR, 6x18 LFR, and 8x21 LFR shall be manufactured in accordance with U.S. Coast Guard Office of Civil Engineering Specification No. 460.

3.4 Welding. The plates, bars, and shapes that form the various components of the buoy shall be fitted and faired prior to being welded in place. All welds shall be as indicated on the drawings.

3.4.1 Steel welding. All steel parts of the buoy shall be welded using Shielded Metal Arc Welding (SMAW), Gas Metal Arc Welding (GMAW), or Submerged Arc Welding (SAW). All weld procedures and weld quality shall meet the requirements of AWS D1.1. All welders shall be qualified by the Contractor to meet the procedures required in AWS D1.1.

3.4.2 Aluminum welding. All aluminum parts of the buoy shall be welded using GMAW. All weld procedures and weld quality shall meet the requirements of AWS D1.2. All welders shall be qualified by the Contractor to meet the procedures required in AWS D1.2.

3.5 Surface preparation. All steel surfaces shall be blast cleaned to near white metal in accordance with SSPC-SP-10. Prior to painting, all surfaces shall be free of contaminants such as oil, water, grease, dirt, blasting residue, weld spatter, slag, rust, etc. All welding, machining, drilling, bending, or any other operation that may damage the protective finish shall be performed prior to the application of the finish.

3.6 Coating system. The buoy coating system shall consist of a protective finish for the steel and aluminum components plus an antifouling paint (when specified) for the underwater portion of the buoy. The steel and aluminum components shall be coated as described below.

3.6.1 Hot dipped galvanized. All steel parts (with the exception of stainless steel bolts and threaded rods) on 4th, 5th, 6th class and Fast Water (FW) buoys shall be hot dip galvanized in accordance with ASTM A153.

3.6.2 Painting. All metal surfaces (with the exception of stainless steel bolts and threaded rods) on the 8x21 LFR, 6x18 LFR, 5x9 LFR, 2nd class, and 3rd class buoys shall be painted with the epoxy primer described in paragraph 3.6.2.1. All exterior metal surfaces above the waterline on the 8x21, 6x18, and 5x9 buoys shall be coated with the marine grade acrylic aliphatic polyurethane described in paragraph 3.6.2.2. In addition, when specified in the delivery order, an ablative antifouling paint shall be applied below the water line as described in paragraph 3.6.2.3. All painting shall be performed after the buoy has been cleaned as specified in paragraph 3.5. The paints in the coating system are commercial products available from a variety of manufacturers. However, they shall be applied as a complete system; i.e., all of the paints used on any given buoy (primer, topcoat, and antifouling) shall be from the same manufacturer. The Contractor shall follow the manufacturer's instructions for mixing, induction, application, and curing of the paint. Sharp corners, edges, and other hard-to-coat areas shall be striped before each full coat is applied.

3.6.2.1 Epoxy primer. The epoxy primer shall meet the requirements of MIL-P-24647, Type I,

Class 1A, Grade A or B, Application 1 or 2, and shall be listed on the latest edition of QPL-24647. The colors shall be haze gray, off-white or buff (manufacturers' standard colors are acceptable). Apply by spraying two coats, 5 mils dry film thickness each, using contrasting colors for each coat (e.g. off-white or buff followed by haze gray).

3.6.2.2 Polyurethane topcoat. This paint shall meet the following requirements: it shall have a Volatile Organic Compound (VOC) content of no more than 340 g/L (2.8 lb/gal), a lead content of less than 0.06% by weight, and a chromium content of less than 0.06% by weight. The required colors (as specified in the delivery order) shall be in accordance with FED-STD-595 as shown in Table II. Apply by spraying one coat, 3 mils dry film thickness.

3.6.2.3 Ablative antifouling paint. When specified, an ablative antifouling paint shall be applied below the waterline to the foam hull section on all classes of buoy plus the underwater steel components on the 8x21 LFR, 6x18 LFR, 5x9 LFR, 2nd class, and 3rd class buoys. This ablative antifouling paint shall meet the requirements of MIL-P-24647, Type I, Class 1A, Grade A or B, Application 1 or 2, and shall be listed in QPL-24647. The colors required are red and black (manufactures standard colors are acceptable). Apply by spraying two coats, 5 mils dry film thickness each, using contrasting colors for each coat (black followed by red). This anti-fouling paint shall not be applied to the galvanized steel components on the 4th, 5th, 6th class and Fast Water buoys.

3.7 Buoy serial numbers. Buoys shall be permanently marked with two lines of alphanumeric characters located on the top of the buoy body or center plate so that they are visible after assembly (see paragraph 3.7.1 and 3.7.2). The first line shall be the letters "USCG". The second line shall consist of the following characters: the buoy type (from Table I); the last two digits of the calendar year in which the buoy was manufactured; the sequential number of the buoy as manufactured; and a two-letter manufacturer's code, all separated by hyphens. For example, the eighth 6th class nun foam buoy built in 2007 would be marked "6NFR-07-08-XX" ("XX" represents the manufacturer's code which will be assigned by the Contracting Officer). The sixteenth 5x9 lighted can buoy built in 2010 would be marked "5X9LCFR-10-16-XX. Each type of buoy shall have its own sequential number series, (i.e., 2NFR buoys shall have a separate sequence of numbers from 2CFR buoys).

3.7.1 Welded serial numbers. Serial numbers on 5x9, 6x18, and 8x21 LFR; 2nd class; and 3rd class buoys shall have the serial numbers welded onto the top of the center plate. The characters shall be not less than 1" in tall and the weld bead shall be 1/8" high.

3.7.2 Engraved serial numbers. All 4th class, 5th class, 6th class, and FW buoys shall have the serial numbers engraved or melted into the foam on top of the buoy body. The characters shall be 2 inches tall and the depth of the markings shall be a minimum of 1/16 inch.

3.8 Retroreflective material. Each buoy shall have retroreflective material attached as shown in the drawings and its color shall match the color of the buoy. The retroreflective material shall be applied in continuous sheets and shall not be spliced. The retroreflective material shall meet the requirements of Coast Guard Office of Civil Engineering Specification No. 393 and the supplier shall be listed on CG-432 internet website: http://www.uscg.mil/systems/gse/gse2/.

3.9 Material certifications. In addition to records required by ASQ Q9002, the Contractor shall maintain and provide access to the material certifications from the manufacturer or certified independent testing laboratories which show that all of the materials used in the first articles and production buoys meet the requirements of this specification.

3.10 Safe water buoy. A Safe Water Buoy shall consist of eight alternating red and white vertical stripes as described below. The retroreflective material shall be white.

3.10.1 Lighted buoys. The 5x9 LFR buoy shall have the aluminum radar reflector painted so that the vertical red and white segments bisect the 90-degree angle of the radar panels. The 6x18 and 8x21 LFR buoys shall have the ionomer foam radar reflector panels colored so that the vertical red and white segments bisect the 90-degree angle of the radar panels. The steel section of the buoy tower on the 5x9 LFR and the aluminum section of the buoy towers on the 6x18 and 8x21 LFR shall be painted red. The buoy body shall consist of densified red and white foam segments covering 45 degrees of arc each. These segments shall cover the outer circumference of the buoy hull with the top surface of the buoy hull being white. The red and white sections of radar reflector and foam buoy body shall be aligned to show the same color.

3.10.2 Unlighted buoys. The can shaped daymark shall be used for the unlighted safe water buoy. The buoy body and daymark shall consist of eight red and white foam segments covering 45 degrees of arc each. These segments shall cover the outer circumference of the buoy hull and daymark with the top surface of the hull and daymark being white. The red and white foam sections of buoy body and daymark shall be aligned to show the same color.

3.11 Preferred channel buoy. A Preferred Channel Buoy shall consist of three horizontal red and green bands as described below. The bands shall be either red/green/red or green/red/green with the top and bottom band designated the primary color and the middle band as the secondary color. The retroreflective material shall be of the primary color. The designation of the primary and secondary colors will be specified in the delivery order.

3.11.1 Lighted buoys. The 5x9 LFR buoy shall be configured as follows: the aluminum radar reflector shall be painted the primary color; the steel section above the foam buoy body (including the battery box) shall be painted the secondary color; and the foam buoy body shall consist of the primary color. The 6x18 and 8x21 LFR buoys shall be configured as follows: The top half of the ionomer foam radar reflector panels shall be colored the primary color; the bottom half of the ionomer foam radar reflector panels shall be colored the secondary color; the aluminum framing on the radar reflector tower section shall be painted to correspond with the ionomer foam color: the primary color on the top half and the secondary color on the bottom half; the steel and aluminum sections above the foam buoy body (including the battery box) shall be painted the secondary color; and the foam buoy body shall consist of the primary color.

3.11.2 Unlighted buoys. The buoy body shall consist of the primary color. The buoy daymark shall consist of two foam pieces heat welded together to form a single unit. On the nun-shaped daymark, the primary color shall extend from the top of the buoy to approximately 2” below the shoulder of the conical section. The secondary color shall consist of the remaining portion of the

cylindrical section of the daymark. The can-shaped daymark shall consist of equivalent portions of primary and secondary color as that of the nun buoy, as shown on the drawings.

3.12 Special markings. When specified in the delivery order, buoys shall be provided with special markings. These include symbols, legends, and retroreflective bands applied to the buoy top as described below. Examples of standard marking configurations are listed in Table V. The specific combination of symbols, legends, and retroreflective bands required for a given buoy will be specified in each delivery order.

3.12.1 Symbols. As specified in the delivery order, symbols shall be a circle, a diamond, or a diamond with a cross in the middle. The symbols shall be fabricated from sheets of retroreflective material meeting the requirements of Coast Guard Office of Civil Engineering Specification No. 393. The outlines of the symbols forming the shape of the circle and rectangle (and the cross within the rectangle) shall be 2 inches wide and orange in color (FED-STD-595 color number 12197). The interior blank space of the symbols shall be white.

3.12.2 Legends. Legends shall consist of characters placed either above, below, or to the side of the symbols. The characters shall be black in color, upper case, and 3 inches in height with a bold Helvetica type font. The actual wording required for a given buoy will be specified in the delivery order.

3.12.3 Retroreflective bands. When specified in the delivery order, two continuous bands of 2-inch wide orange retroreflective material shall be placed around the circumference of the buoy, once below and one, above the legend and symbol. The retroreflective material shall meet the requirements of Coast Guard Office of Civil Engineering Specification No. 393, and the color shall be FED-STD-595 number 12197.

Table V Special Markings – Standard Configurations

Symbols	Legends
Orange Circle	CONTROLLED AREA
Orange Diamond	HAZARD WARNING
Orange Diamond with Cross	RESTRITED AREA/EXCLUSION
Orange Diamond	DANGER SHOREWARD
Orange Diamond with Cross	COAST GUARD SECURITY ZONE KEEP OUT

4. VERIFICATION

4.1 General. The Contractor shall establish a quality assurance program prior to commencing production of buoys. This quality assurance program shall conform to the requirements of ASQ Q9002 and the Contractor shall maintain and adhere to these requirements throughout the length of the contract. **The Contractor DOES NOT have to be Q9002 certified.**

4.1.1 Quality Manual. The Contractor shall maintain a Quality Manual and provide access to the procedures, instructions, records, and test results required by ASQ Q9002. These documents

shall describe the Contractor's quality control organization, the inspections and tests which the Contractor intends to perform, and the methods by which the Contractor will identify and correct defects in the buoys and in the buoy production process.

4.2. First articles. The Contractor shall provide the following as first articles for inspection:

a. Material certifications as specified in paragraph 3.9.
b. One 3NFR buoy, complete with all steel members and fasteners.
c. The ionomer foam samples listed in Table VI for the tests described in paragraphs 3.2.7 through 3.2.15.

Table VI First Article Foam Samples

Test	Size	Density	Quantity
Colorfastness	6" x 6" x 0.25"	30 pcf	2 red 2 yellow 2 dark green 2 light green 2 white
Density	1" x 1" x 1"	4 pcf 30 pcf	5 5
Tensile Strength	6" x 1.6" x 0.13" (die A cut)	4 pcf	5 - horizontal direction 5- vertical direction 5 - radial direction
Tear Strength	6" x 1.6" x 0.13" (die C cut)	4 pcf	5 - horizontal direction 5- vertical direction 5 - radial direction
Compression Set	2" x 2" x 1"	4 pcf	5
Compression Load Deflection	4" x 4" x 1"	4 pcf	5
Hardness	2" x 2" x 0.25"	30 pcf	5
Abrasion Resistance	1" x 1" x 0.25"	30 pcf	5
Water Absorption	Cylinder 6" x 1.5" x 12"	4 pcf 30 pcf outer skin	2

4.3 Classification of inspections. The inspection requirements specified herein are classified as

follows:

a. First article inspection (paragraph 4.4)
b. Contractor production inspection (paragraph 4.5)
c. Coast Guard production inspection (paragraph 4.6)

4.4 First article inspection. The Contractor shall conduct tests on the first article 3NFR buoy as described in paragraph 4.4.3 (and all associated subparagraphs). The Contractor shall employ an independent testing laboratory to conduct tests on the first article foam samples as described in paragraphs 3.2.7 through 3.2.15, 4.4.1, and 4.4.2.

4.4.1 Colorfastness. Samples shall be prepared in accordance with the test procedure described in paragraph 3.2.7 and exposed for the required period of time in a weatherometer. The weathering cycle shall be 40 minutes of light, followed by 20 minutes of light with front water spray, 60 minutes of light, followed by 60 minutes of dark with front and back water spray.

Parameters for the test cycle shall be as follows:

Filters:	Quartz Inner and Type S Borosilicate Outer
Irradiance:	.55 W/m^2 @ 340 nm
Black Panel Temperature:	70°C (light cycle), 38°C (dark cycle)
Dry Bulb Temperature:	47°C (light cycle), 38°C (dark cycle)
Relative Humidity:	50% (light cycle), 95% (dark cycle)

Samples that do not meet the requirements of paragraph 3.2.5 after 2000 hours of testing will be considered to have failed.

4.4.2 Water absorption test. The two cylindrical samples shall be weighed and then completely submerged in water for a continuous period of 72 hours. All portions of the samples shall be at least six feet below the surface of the water. The samples shall then be recovered, dried off, and re-weighed within two hours of recovery from the water. The weight gain shall be no greater than 15 percent of the original dry weight. Samples that do not meet this requirement will be considered to have failed the test.

4.4.3 First Article 3NFR buoy inspection. First article inspection and testing of the completed buoy shall be at the Contractor's facility and will be witnessed by the Contracting Officer's Technical Representative (COTR). Upon completion of the impact resistance test and heat seal inspection, the buoy shall meet the requirements of paragraph 3.2.6 or it will be considered to have failed the inspection.

4.4.3.1 Visual inspection. Prior to conducting the impact resistance test and heat seal inspection described below, the buoy shall be visually inspected for quality workmanship and conformance to this specification and the drawings. The inspection shall include surface finish of the foam, dimensions, marking, mechanical fit, part alignment, surface preparation, and painting.

4.4.3.2 Welds. Welds shall be visually inspected for quality in accordance with AWS D1.1 and D1.2. Weld inspections shall be performed prior to hot-dip galvanizing or application of paint.

4.4.3.3 Impact resistance test. The first article buoy shall be dropped onto a paved surface from a height of ten feet in both a horizontal and diagonal orientation. The test shall be performed twice in the horizontal and twice in the diagonal orientation.

4.4.3.4 Heat seal inspection. Once the buoy passes the impact resistance test above, the Contractor shall disassemble the buoy and, at the discretion of the COTR, cut it into various sections radially, vertically, or horizontally. The buoy shall then be inspected for quality of the heat seals, integrity of the lamination, and adhesion of the foam layers. The Contractor may re-use the metal hardware for future production buoys.

4.4.4 Material certifications inspection. The Contractor shall ensure that all materials used in the first articles meet the requirements of this specification. Material certifications required by paragraph 3.9 shall be maintained at the contractor's plant and be available for review by the COTR. First articles that do not meet the material requirements of this specification will be considered to have failed the inspection.

4.4.5 First article test report. The Contractor shall submit a test report after the completion of first article tests and inspections (see Contract Data Requirements List (CDRL) A001). The report shall include the results of all first article tests and inspections required by this specification, as well as copies of the material certifications required by paragraph 3.9.

4.5 Contractor production inspection. The Contractor shall perform all the inspections and tests as specified in paragraphs 4.5.1 through 4.5.3 to ensure conformance to this specification. The Contractor shall provide space, personnel, and test equipment to conduct all inspections and tests as required. The inspections required by this specification are not intended to supplant any controls, inspections, or tests normally used by the Contractor to assure product quality.

4.5.1 Visual inspection. All buoys shall be visually inspected for quality of workmanship and conformance to the specification and drawings. The inspection shall include surface finish of the foam, dimensions, marking, mechanical fit, part alignment, surface preparation, and painting.

4.5.2 Welds. Welds shall be visually inspected for quality in accordance with AWS D1.1 and D1.2. Weld inspections shall be performed prior to hot-dip galvanizing or application of paint.

4.5.3 Material. The Contractor shall ensure that all materials used in the production buoys conform to the requirements of this specification, and shall maintain material certifications for review by the COTR as required in paragraph 3.9.

4.6 Coast Guard production inspection. The Coast Guard will periodically verify quality of production buoys by performing the inspections described in paragraphs 4.6.1 through 4.6.4.

4.6.1 Visual inspection. All buoys shall be visually inspected for quality of workmanship and conformance to the specification and drawings. The inspection shall include surface finish of the foam, dimensions, marking, mechanical fit, part alignment, surface preparation, and painting.

4.6.2 Welds. Welds shall be visually inspected for quality in accordance with AWS D1.1 and D1.2. Weld inspections shall be performed prior to hot-dip galvanizing or application of paint.

4.6.3 Material certification inspection. The COTR will review the material certifications required by paragraph 3.9 for conformance with this specification. If any material fails to meet the requirements of this specification, each item made from the material will be rejected.

4.6.4 Foam sample inspection. At the COTR's discretion, the Coast Guard will perform the tests described in paragraphs 3.2.7 through 3.2.15, taking test samples from production buoys. The Coast Guard will bear the costs of these foam inspections. If the foam fails any of the tests described, the entire lot will be rejected and shall not be resubmitted. The term "lot" shall refer to all buoys made from the same batch of ionomer resin.

SPECIFICATION FOR FABRICATION OF IONOMER FOAM BUOYS

SPECIFICATION NO. 450F

AUGUST 2007

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